Docket No. SA-537

Exhibit Nos. 10-A,
10-B,
10-C

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

Flight Data Recorder

Factual Report of Group Chairman

(30)

Exhibit 10-A FDR Group Chairman's Factual Report
Exhibit 10-B Attachment 1 – CSV Data From FDR
Exhibit 10-C Attachment 2 - CSV Data From QAR

NATIONAL TRANSPORTATION SAFETY BOARD
Vehicle Recorder Division
Washington, D.C. 20594

November 20, 2013

Flight Data Recorder - 10

Group Chairman's Factual Report
By Greg Smith

1. EVENT SUMMARY

Location: San Francisco, California
Date: July 06, 2013
Aircraft: Boeing 777-200
Registration: HL7742
Operator: Asiana Airlines
NTSB Number: DCA13MA120

On July 6, 2013 at 11:28 am Pacific daylight time, a Boeing 777, registration HL7742, operated by Asiana Airlines as flight 214, struck the seawall short of runway 28L at San Francisco International Airport. The airplane was destroyed by impact forces and fire. Three of the 291 passengers were fatally injured and about 199 were transported to the hospital with injuries. One of the 4 flight crew and 10 of the 12 cabin crewmembers were injured. The flight was a regularly scheduled passenger flight from Incheon International Airport, Seoul, Korea, and was operated under the provisions of 14 *Code of Federal Regulations* Part 129. Visual meteorological conditions prevailed at the time of the accident.

2. FLIGHT DATA RECORDER GROUP

A flight data recorder (FDR) group was convened on July 9-11, 2013.

Chairman: Greg Smith
Aerospace Engineer
National Transportation Safety Board

Member: Nathan Rohrbaugh
Flight Data Lab Analyst
Federal Aviation Administration

Member: Albert T. Stephens
Lead Engineer, Aerodynamics Accident/Incident Investigation
The Boeing Company

Member: James D. Vanden Brook
Flight Controls – Autoflight
The Boeing Company

Member: Kyoo Won Lee
Investigator
Aviation and Railway Accident Investigation Board
Republic of Korea

Member: Capt Jin Ho Kim
Investigator, Safety Management
Asiana Airlines

3. FDR CARRIAGE REQUIREMENTS

The event aircraft, HL7742, was manufactured in February 2006, and was operating such that it was required to be equipped with an FDR that recorded, at a minimum, 88 parameters, as cited in Title 14 CFR Part 121.344 by reference from Title 14 CFR Part 129.20.

4. DETAILS OF FLIGHT DATA RECORDER INVESTIGATION

The Safety Board's Vehicle Recorder Division received the following data recorders:

FDR
Recorder Manufacturer/Model: **Honeywell 4700 (256 wps)**
Recorder Serial Number: **SSFDR-11519**

Quick Access Recorder (QAR)
Recorder Manufacturer/Model: **Teledyne OQAR**
Recorder Serial Number: **00975**

4.1. FDR - Honeywell 4700 (256 wps) Description

The Honeywell Solid State Flight Data Recorder (SSFDR) records airplane flight information in a digital format using solid-state flash memory as the recording medium. The SSFDR can receive data in the ARINC 573/717/747 configurations and can record a minimum of 25 hours of flight data. It is configured to record 256 12-bit words of digital information every second. Each grouping of 256 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync) word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 256-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The SSFDR is designed to meet the crash-survivability requirements of TSO-C124.

4.1.1. FDR Condition

The FDR was in good condition and the data were extracted normally from the recorder.

4.1.2. FDR Recording Description

The FDR recording contained approximately 27 hours of data. Timing of the FDR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second. The event flight was the last flight of the recording and its duration was

approximately 10 hours and 50 minutes. The parameters evaluated for the purpose of this report appeared to be in accordance with the federal FDR carriage requirements.

4.1.3. FDR Engineering Units Conversions

The engineering units conversions used for the data contained in this report are based on documentation from the aircraft manufacturer. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).[1]

Appendix A lists the FDR parameters verified and provided in this report.

4.1.3.1. Pressure Altitude

This FDR records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the FDR plots and in the electronic data has not been corrected for the local altimeter setting at the time of the event.

In order to capture altitude at a high enough resolution over the entire range required, the pressure altitude parameter was stored as two components in different locations in the data map. The most significant part (MSP) is stored only once every 4 seconds while the least significant part (LSP) is stored every second. To determine the combined total pressure altitude, the MSP and LSP of the parameter are concatenated and converted to engineering units. Because the MSP was stored at a lower rate than the LSP, the resultant combined parameter data often had spikes of one to three samples as the parameter value passed through a point where the LSP wrapped. These spikes have not been corrected in the plotted or tabular data.

4.1.3.2. Latitude and Longitude

In order to capture latitude and longitude at a high enough resolution over the entire range required, the FDR recorded two components for each parameter at different resolutions. The coarse resolution (identified as the MSP) covered the entire range for the parameter while the fine resolution (identified as the LSP) covered only a fraction of a degree before wrapping. To determine the combined total latitude or longitude, the MSP and LSP of each parameter were added together. Latitude and longitude data included in the plotted data has been combined, however only the MSP and LSP of each respective parameter are included in the tabular data attached to this report.

4.2. QAR - Teledyne Optical QAR Description

The Teledyne Optical QAR (OQAR) records airplane flight information in a digital format using an optical disk as the recording medium. The OQAR receives data in the ARINC 717 configuration and can record up to 155 hours of flight data. It is configured to record 512 12-bit words of digital information every second. Each grouping of 512 words (each second) is called a subframe. Each subframe has a unique 12-bit synchronization (sync)

[1] CRT=+ means that for any parameter recorded that indicates a climb or a right turn, the sign for that value is positive. Also, for any parameter recorded that indicates an action or deflection, if it induces a climb or right turn, the value is positive. Examples: Right Roll = +, Pitch Up = +, Elevator Trailing Edge Up = +, Right Rudder = +.

word identifying it as either subframe 1, 2, 3, or 4. The sync word is the first word in each subframe. The data stream is "in sync" when successive sync words appear at proper 512-word intervals. Each data parameter (e.g. altitude, heading, airspeed) has a specifically assigned word number within the subframe. The primary function of the OQAR is to provide the operator a user configurable set of flight data similar to that of the FDR. It is not crash hardened.

4.2.1. QAR Condition

The QAR was in good condition and the data were extracted normally from the recorder.

4.2.2. QAR Recording Description

Unlike FDR data, QAR data does not wrap within the data file. The QAR begins writing at the start of the data file when the media is replaced, overwriting as it fills the file. This typically results in one or more segments of data from prior installations of the recording media at the end of the data file. The label on the removable optical disk indicated that it was installed the morning of the accident flight. The QAR recording contained a total of approximately 33.7 hours of data, 14.7 hours of which was data from the current installation of the recording media. The event flight was the third[2] flight of the recording and its duration was approximately 10 hours and 49 minutes. Timing of the QAR data is measured in subframe reference number (SRN), where each SRN equals one elapsed second.

The QAR recording ends approximately 52 seconds before the end of the FDR recording. The reason the QAR data ended earlier than the FDR data is buffering at multiple points in the QAR data stream.

4.2.3. QAR Engineering Units Conversions

The engineering units conversions used for the QAR data contained in this report are based on documentation from the operator. Where applicable, the conversions have been changed to ensure that the parameters conform to the NTSB's standard sign convention that climbing right turns are positive (CRT=+).

Appendix B lists the QAR parameters verified and provided in this report.

4.2.3.1. Pressure Altitude

This QAR records pressure altitude, which is based on a standard altimeter setting of 29.92 inches of mercury (in Hg). The pressure altitude information presented in the QAR electronic data has not been corrected for the local altimeter setting at the time of the event.

[2] QAR disks are routinely replaced as part of normal operations. When the disk is replaced the QAR begins recording at the start of the file allocated for data storage. Data in the file beyond the end of the accident flight contained recorded date/time stamps prior to the installation of the disk in the accident aircraft.

4.3. Time Correlation

Correlation of the FDR data from FDR SRN to the event local time, Pacific Daylight Time (PDT), was established by the Aircraft Performance Specialist in the Aircraft Performance Study such that:

FDR SRN 96241.6701 = 11:00:00.256 PDT

Correlation of the QAR data from QAR SRN to the event local time was established by using the QAR and FDR recorded Time GMT[3] hours, Time GMT Minutes, and Time GMT Seconds parameters to correlate the QAR data to the FDR data then applying the offset from the aircraft performance specialist. The correlation from FDR to QAR is:

FDR SRN 97270 = QAR SRN 52219

Accordingly, the time offset for the event flight data from FDR and QAR SRN to local PDT is the following:

PDT = FDR SRN – 56641.4141 = QAR SRN – 11591.4141.

Therefore, for the rest of this report, all times are referenced as PDT, not SRN.

4.4. Observations and Plots

The FDR Group compiled the following observations based upon validated data from the accident aircraft's flight data recorder.

4.4.1. Summary of Observations

The group examined most parameters over the time period from approximately 10,000' on approach through the end of the recording. Some parameters were reviewed for the timeframe during, or prior to, take-off for validation purposes.

- The aircraft descended through 10,000' at about 210 knots approximately 10 minutes and 12 seconds prior to impact (~11:17:38 PDT). At this time the aircraft configuration was flaps up, gear up, and the gross weight was approximately 425,000 lbs. The aircraft auto flight systems were in auto throttle (AT) "Thrust" mode and autopilot (AP) "Flight Level Change" (FLCH) pitch mode.

- At about 11:18:46 PDT, the AP pitch mode changed to "Altitude Capture", the AT mode changed to "Speed" and the aircraft leveled off at 9,000' (the selected altitude).

- At about 11:19:28 PDT the selected altitude changed to 6,000'. Approximately 4 seconds later the AP pitch mode changed to "FLCH", the AT mode changed to "Thrust", and the aircraft began a series of 4 left turns over the next four and a half minutes to maneuver onto the final approach heading.

[3] GMT is Greenwich Mean Time which is also known as Coordinated Universal Time (UTC).

- Over the six seconds after the change in AT mode the thrust lever angles decreased to about 34 degrees. At the end of the six seconds the AT mode changed to “Hold”.

- At about 11:21:00 selected altitude changed to 4,000’. The aircraft continued its descent while the AP pitch mode remained in “FLCH” and AT mode remained in “Hold”.

- At about 11:21:03 PDT the speed brake handle position indicated that the speed brakes were extended for about 54 seconds.

- At about 11:22:11 PDT the autopilot/flight director system localizer mode changed to “Armed”.

- At about 11:22:28 PDT the localizer deviation parameters indicated that the aircraft was intercepting the localizer.

- At about 11:22:48 PDT the selected altitude changed to about 3,000’.

- Localizer capture occurred at about 11:22:51 PDT.

- At about 11:23:02 PDT the selected altitude was set to about 1800’.

- Flap handle was set to detent 1 at about 11:23:10 PDT.

- Starting about 11:23:16 PDT the selected airspeed changed from 212 knots to 172 knots over the next 35 seconds.

- At about 11:23:45 PDT the flap handle was set to detent 5.

- At about 11:23:57 PDT the AP pitch mode changed to “Vertical Speed” and the AT mode changed to “Speed” mode. The airspeed was about 195 knots and the selected airspeed was 172 knots. The vertical speed recorded was about -400 ft/min and the selected vertical speed was about -1000 ft/min.

- About 3 minutes prior to impact the gear handle was selected down (about 11:24:53 PDT)

- At about 11:25:45 PDT, the selected altitude was changed from about 1800’ to about 3000’; the radio altitude was about 2350’.

- At about 11:26:05 PDT the flap handle was set to detent 20.

- At about 11:26:25 PDT and about 1600’ radio altitude, the AP pitch mode changed from “Vertical Speed” to “FLCH” and the AT mode changed from “Speed” to “Thrust.”

- The aircraft responded by starting a climb toward 3000' (the selected altitude), as seen in AP pitch commands, a slight increase in thrust lever angles, and a slight pitch up.

- About 4 seconds after the mode changes (11:26:29 PDT), the AP was disengaged and the flight director began displaying pitch-up commands, providing guidance to climb to the selected altitude.

- The flap handle was set to detent 30 at about 11:26:30 PDT.

- About 2 seconds later (11:26:32 PDT), the AT mode changed from "Thrust" to "Hold" after the thrust lever angles returned to about 34 degrees (~1475' radio altitude).

- At about 11:26:37 PDT and about 1400' radio altitude, the airspeed was approximately 170 knots and the selected airspeed was changed to 137 knots.

- At about 1240' radio altitude (about 11:26:45 PDT), the captain's flight director switch was selected "off", the first officer's flight director switch remained "on", and they remained in those states until the end of the recording.[4] The autopilot/flight director system mode did not change again for the duration of the recording. The AT mode did not change until about 11:27:44 PDT.

- At about 1000' radio altitude (11:26:55 PDT), the airspeed was approximately 149 knots.

- At about 11:27:05 PDT the descent rate was momentarily -1776 ft/min. This was the highest descent rate in the last 2.5 minutes of the flight. From this point forward the descent rate gradually decreased to -608 ft/min at impact and pitch attitude began to increase until the stick shaker activated about 4 seconds before impact.

- At about 500' radio altitude (11:27:15 PDT), the airspeed was approximately 134 knots, 3 knots below the selected airspeed.

- At about 11:27:31 PDT stall protection function activated. It reached a peak value about 15 seconds later.

- At about 11:27:43 PDT, seven seconds prior to impact, the thrust levers moved forward and the AT mode changed from "Hold" to "Thrust." The radio altitude was about 125' and airspeed was approximately 112 knots.

- At about 3 seconds prior to impact (11:27:47 PDT), the FDR recorded the lowest airspeed during the approach of approximately 103 knots and the stick shaker activated. At this time N1 was increasing through 50% and pitch attitude reached about 12 degrees, the highest value of the last 2.5 minutes.

[4] The FDR recorded the flight director switch positions once every four seconds. The timing of the switch position change was verified with the QAR data which recorded the switch positions once per second.

- All three acceleration parameters recorded spikes at approximately 11:27:50 PDT indicating the initial impact. Both engines N1 were at approximately 92% increasing at this time. At impact, the airspeed was approximately 106 knots.

- Recording continued for approximately 11 seconds (~ 11:28:01 PDT).

4.4.2. Plots and Tabular Data

The following 15 figures contain FDR data recorded during the July 6, 2013, event which support the findings above. The following plots do not include all parameters and time ranges evaluated by the group.

These figures are configured such that right turns are indicated by the trace moving toward the bottom of the page, left turns towards the top of the page, and nose up attitudes towards the top of the page.

The tabular data used to create these 15 plots are provided in compressed (zipped) electronic (csv[5]) format as Attachment 1 to this report. The tabular data contains additional parameters and time ranges that were validated but not plotted.

A few parameters from the QAR which provide supplemental data to the FDR were reviewed and are included in compressed electronic (csv) tabular data format as Attachment 2 to this report.

[5] Comma Separated Value.

Figure 1 - Basic parameters from 11,000' through the end of the recording.

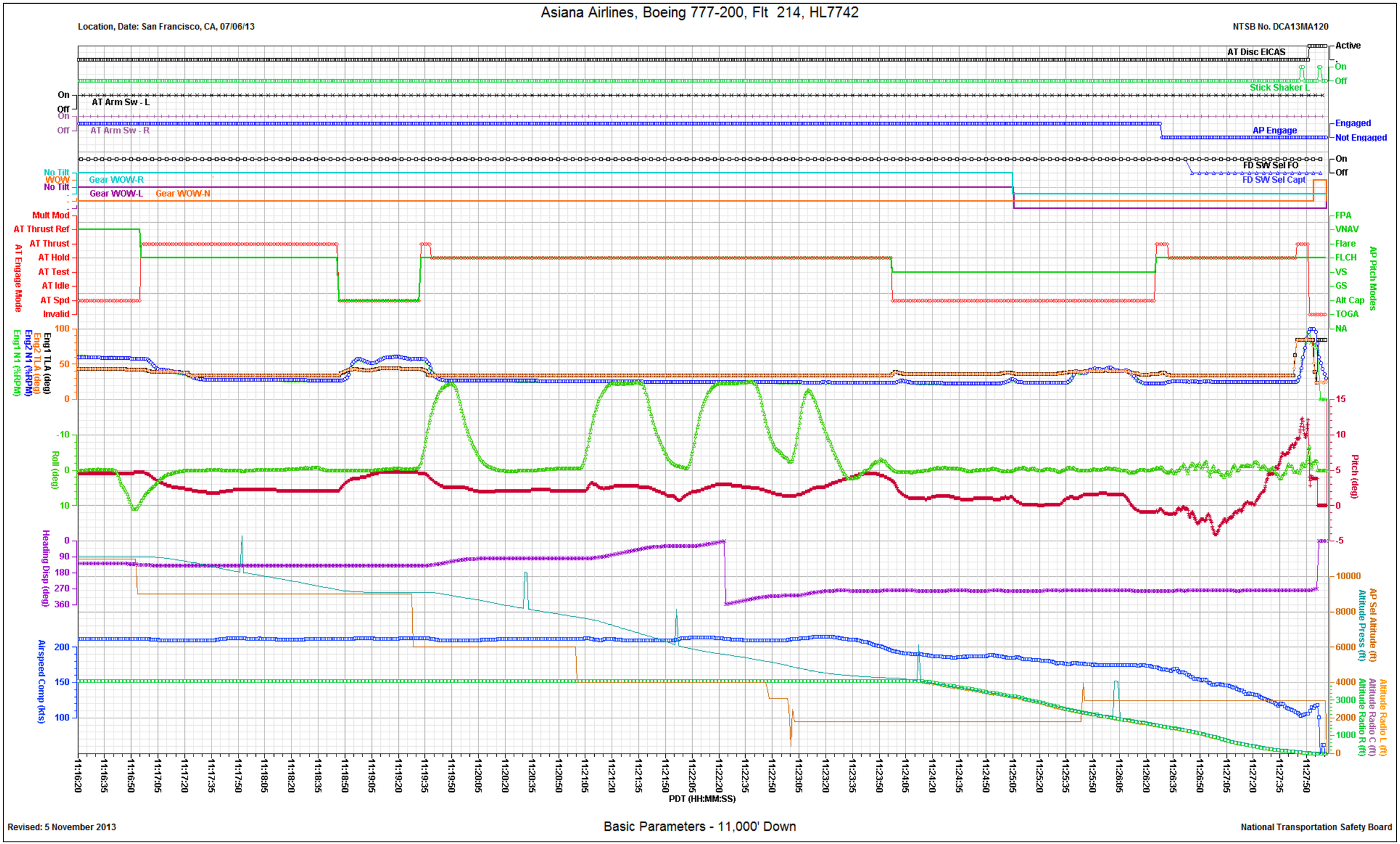


Figure 2 - Basic parameters for the last 2.5 minutes of flight.

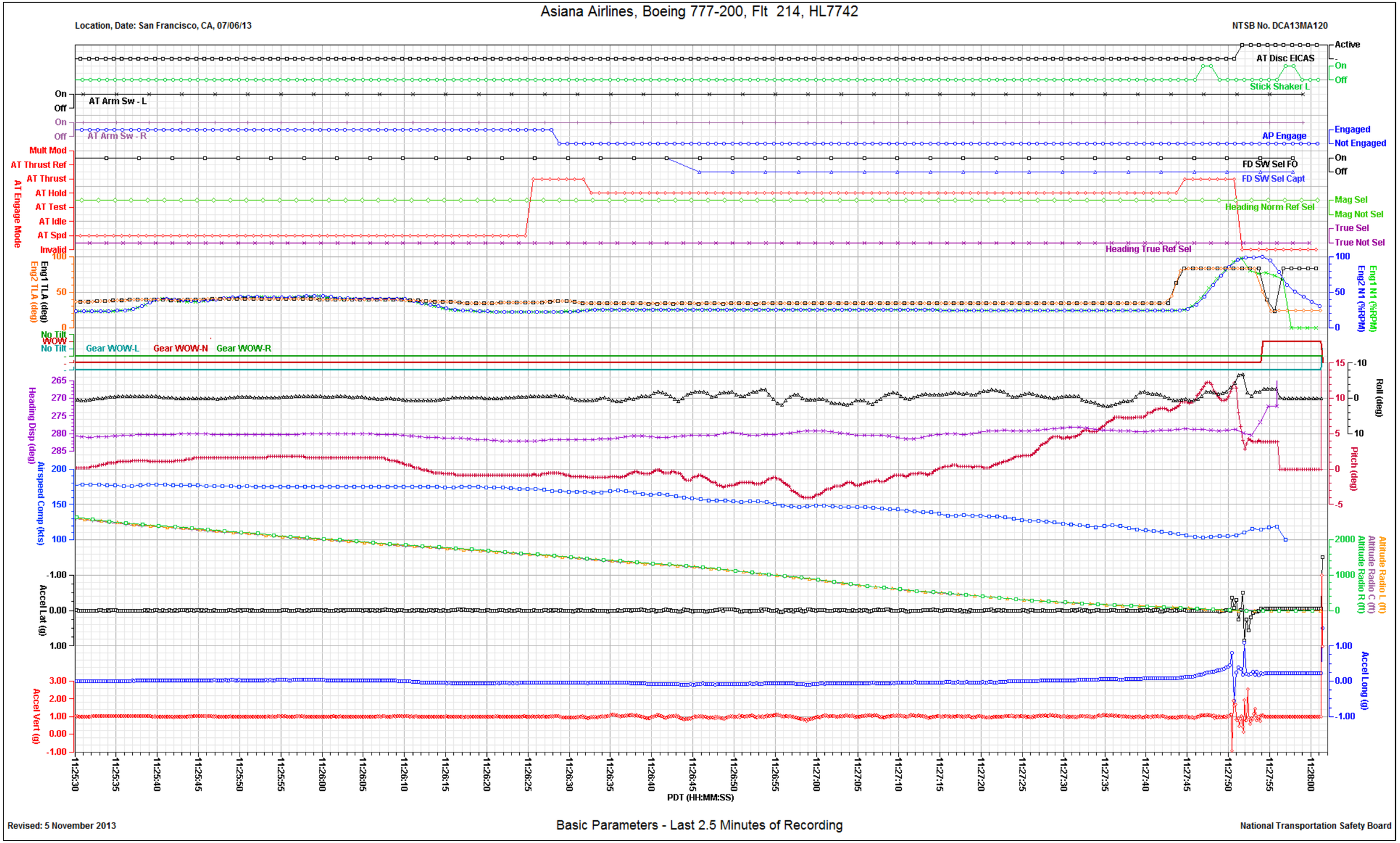


Figure 3 - Auto-flight parameters for the last 2.5 minutes of the flight.

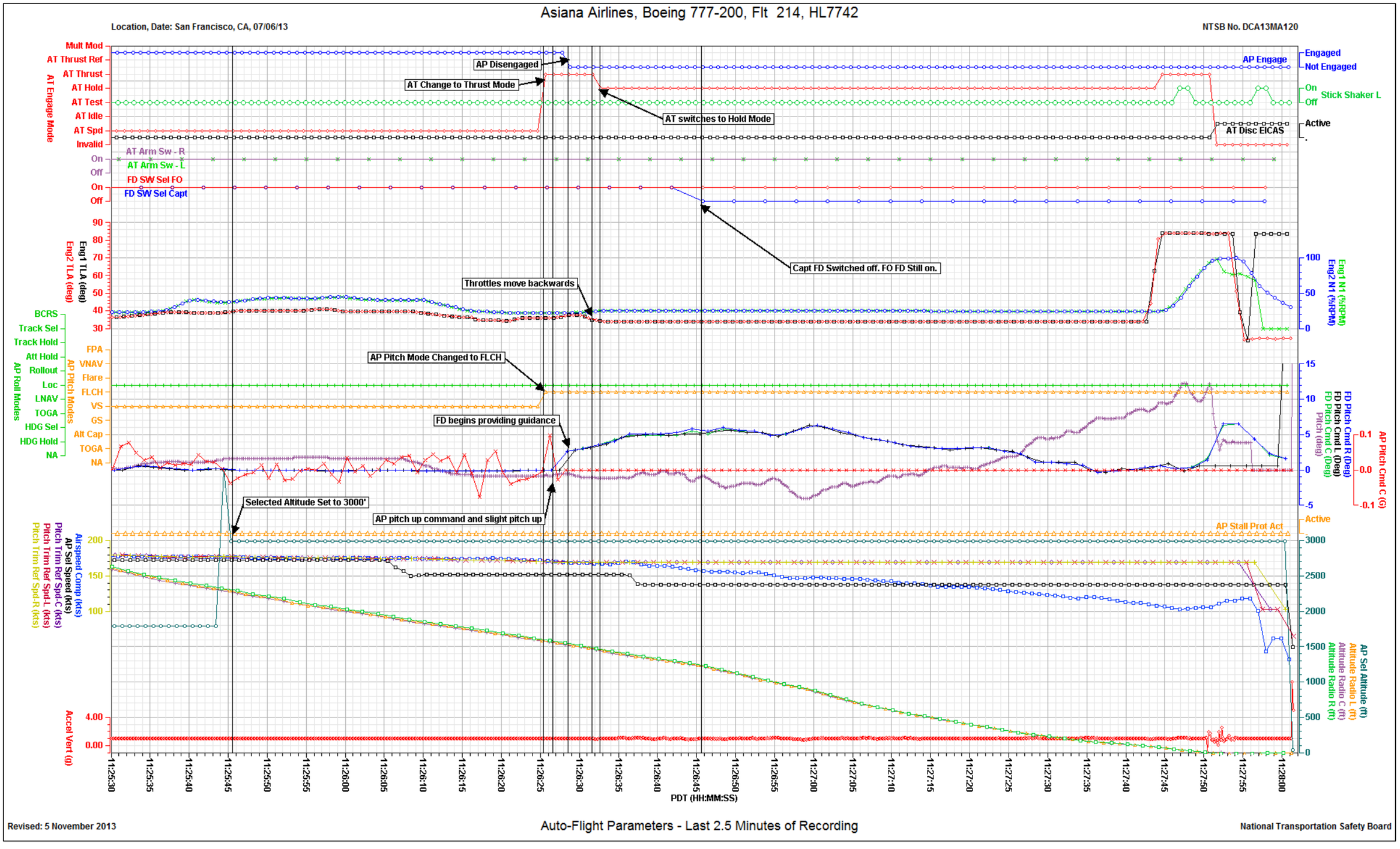


Figure 4 - Additional auto-flight parameters for the last 2.5 minutes of the flight.

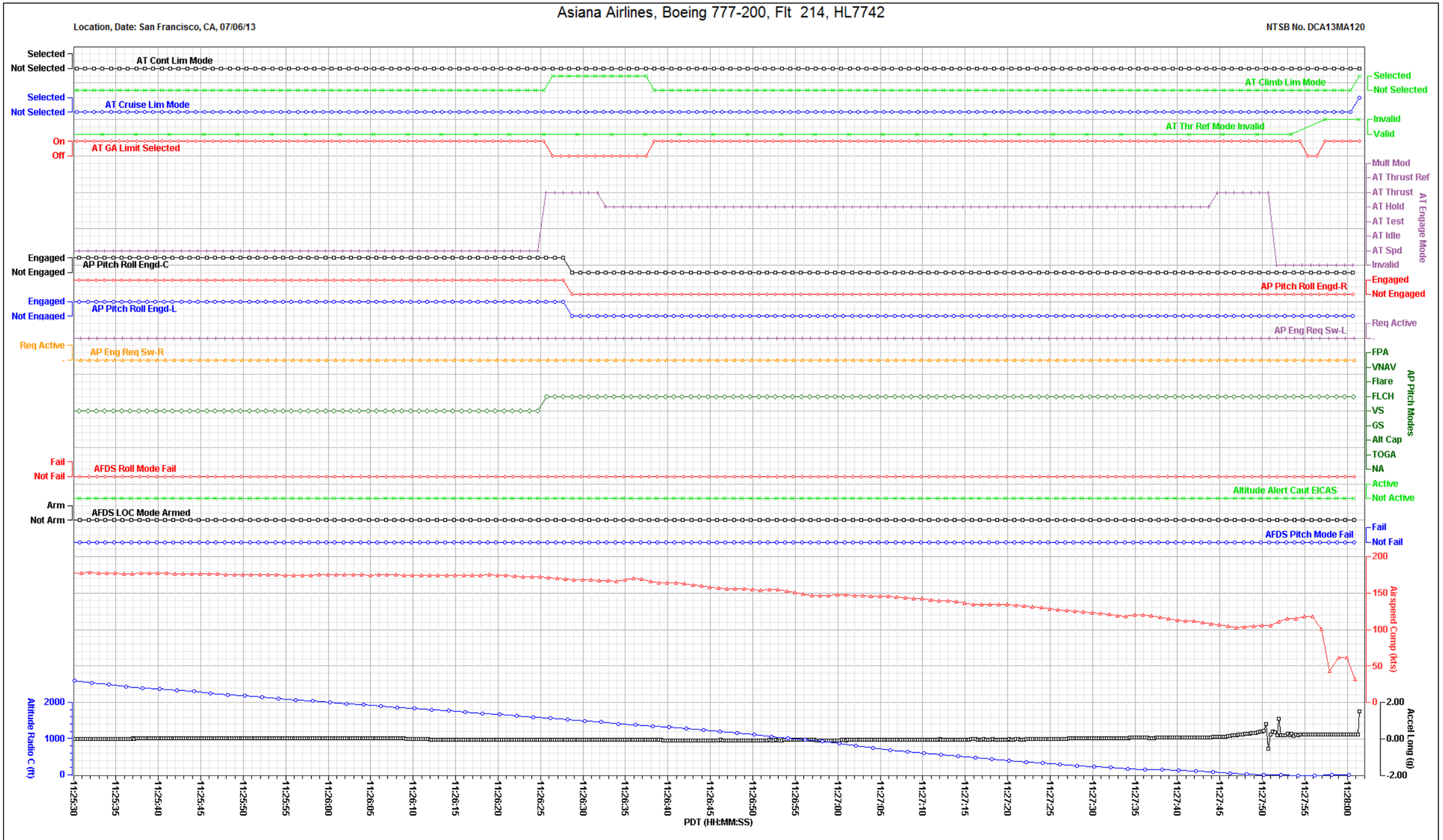


Figure 5 - Engine 1 parameters for the last 2.5 minutes of the flight.

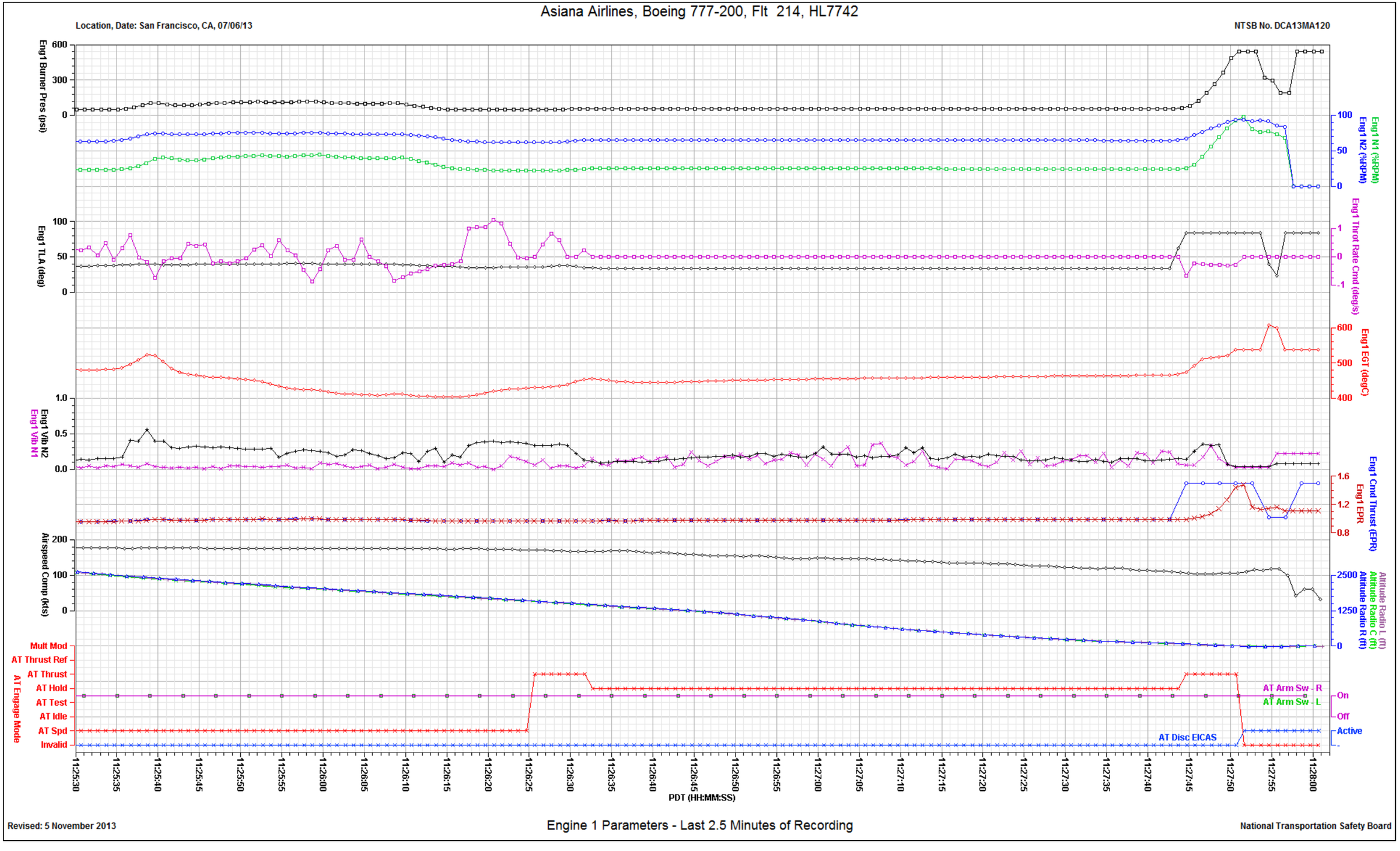


Figure 6 - Engine 2 parameters for the last 2.5 minutes of the flight.

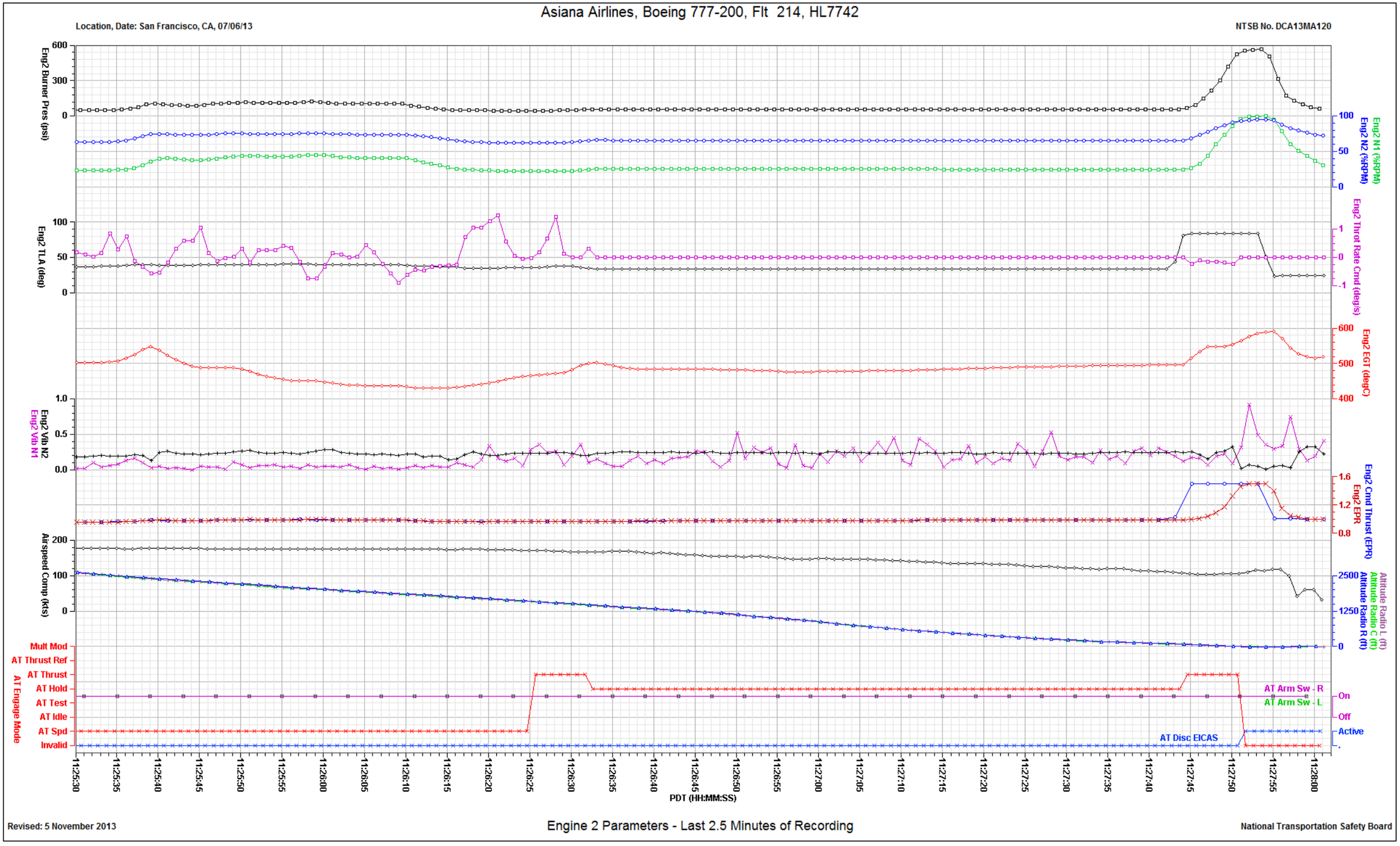


Figure 7 - Pitch related parameters for the last 2.5 minutes of the flight.

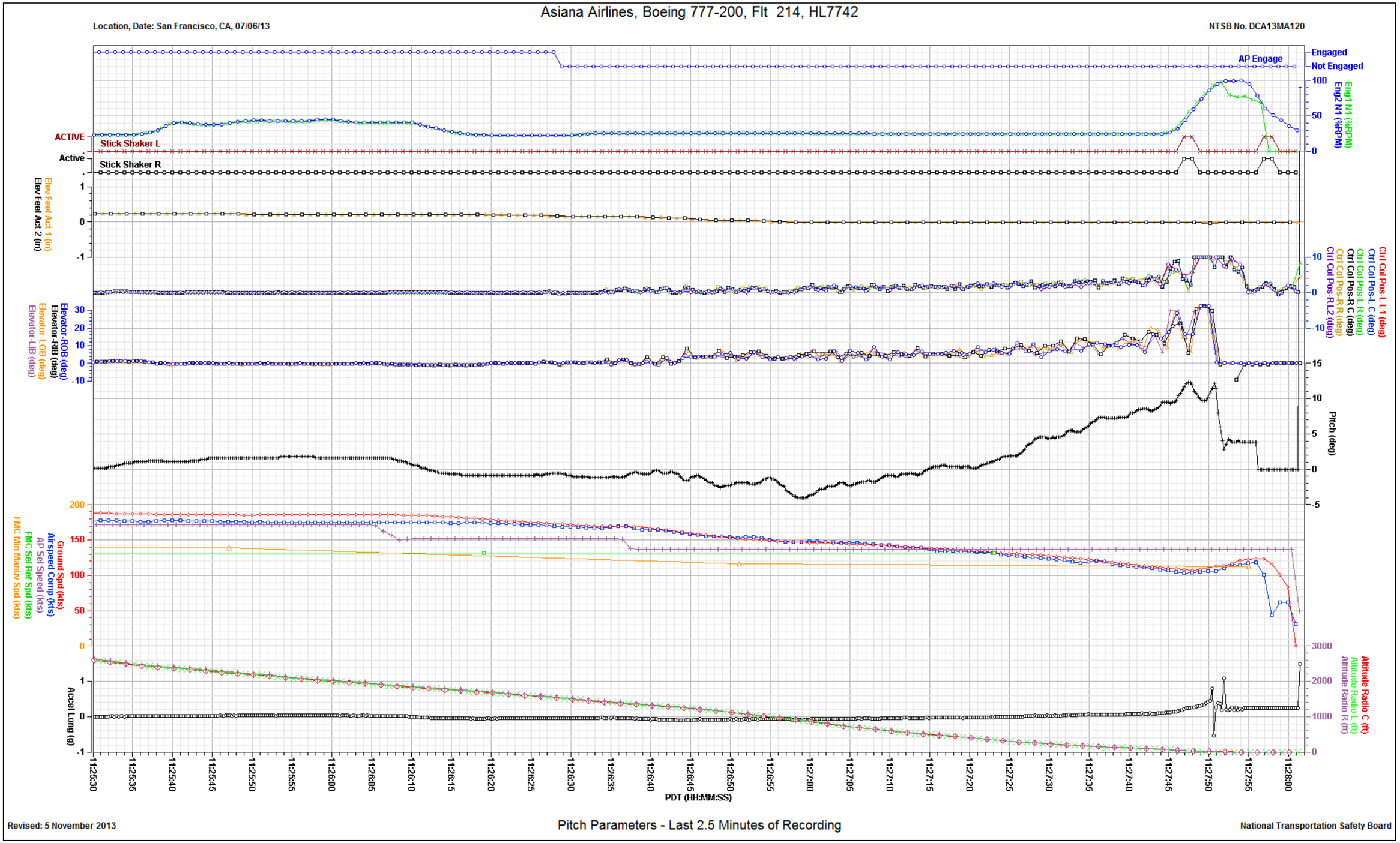


Figure 8 - Roll and yaw related parameters for the last 2.5 minutes of the flight.

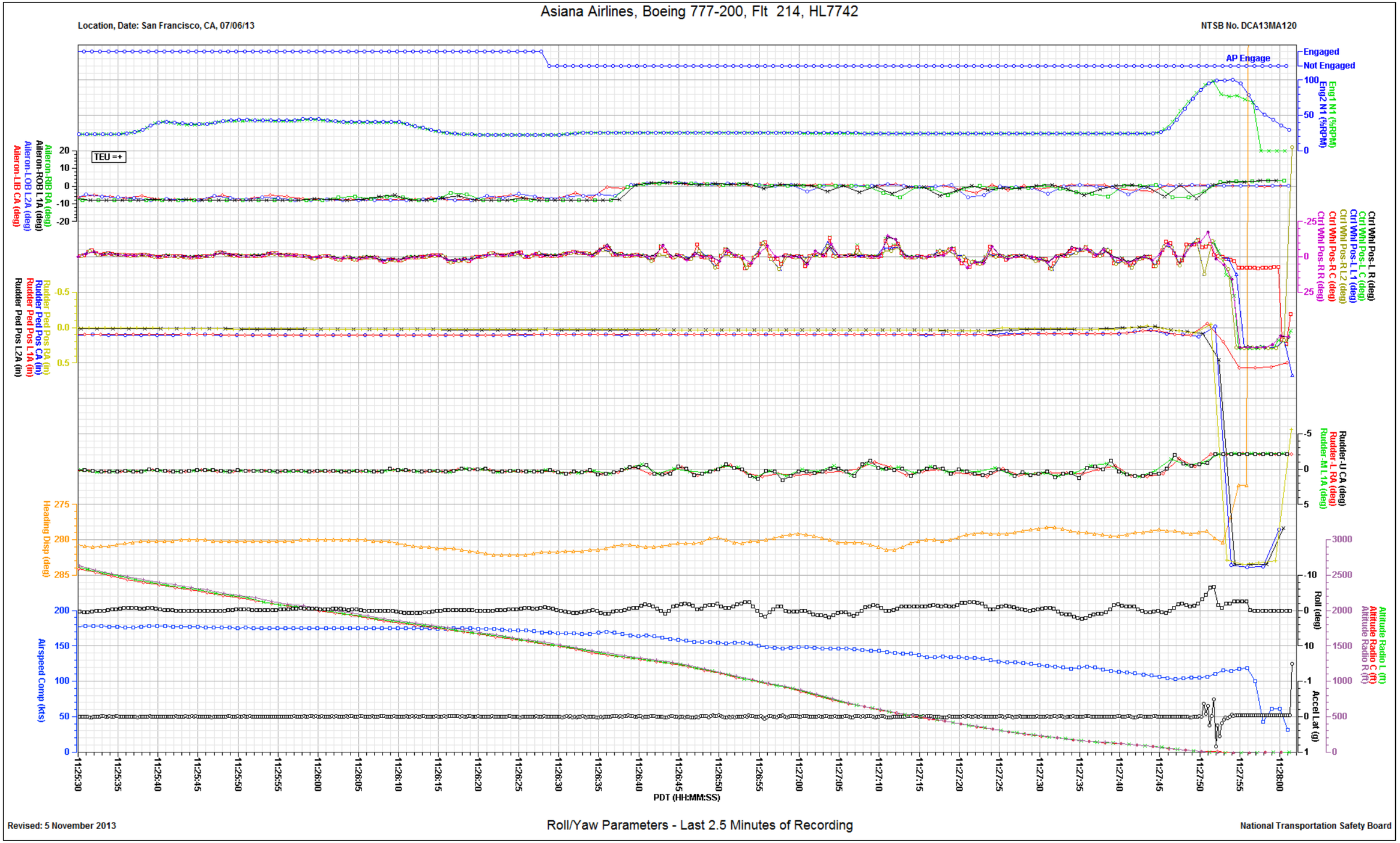


Figure 9 - Localizer deviation, control input forces and related parameters from 11,000' through the end of the recording.

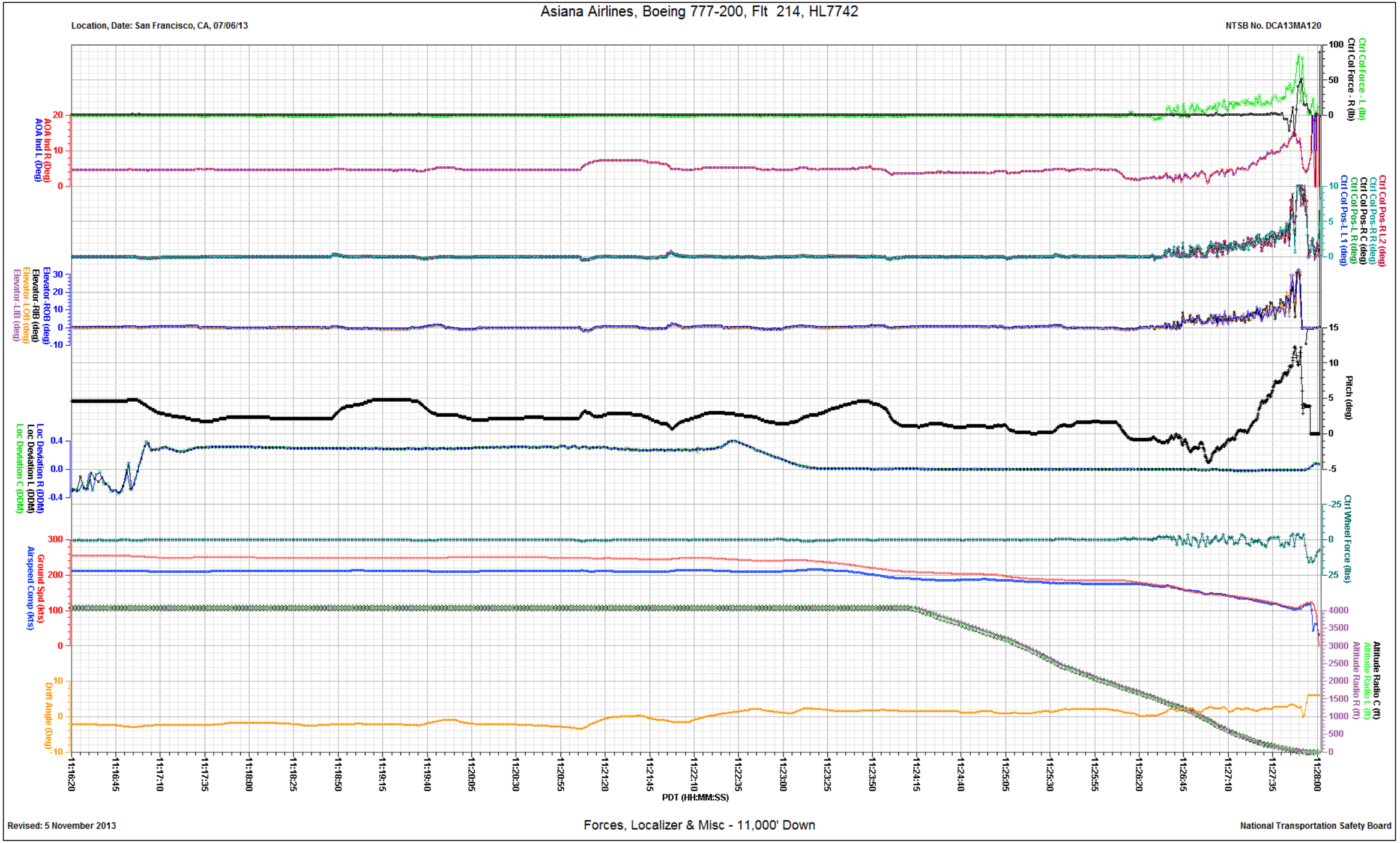


Figure 10 - Flap, flaperon and related parameters from 11,000' through the end of the recording.

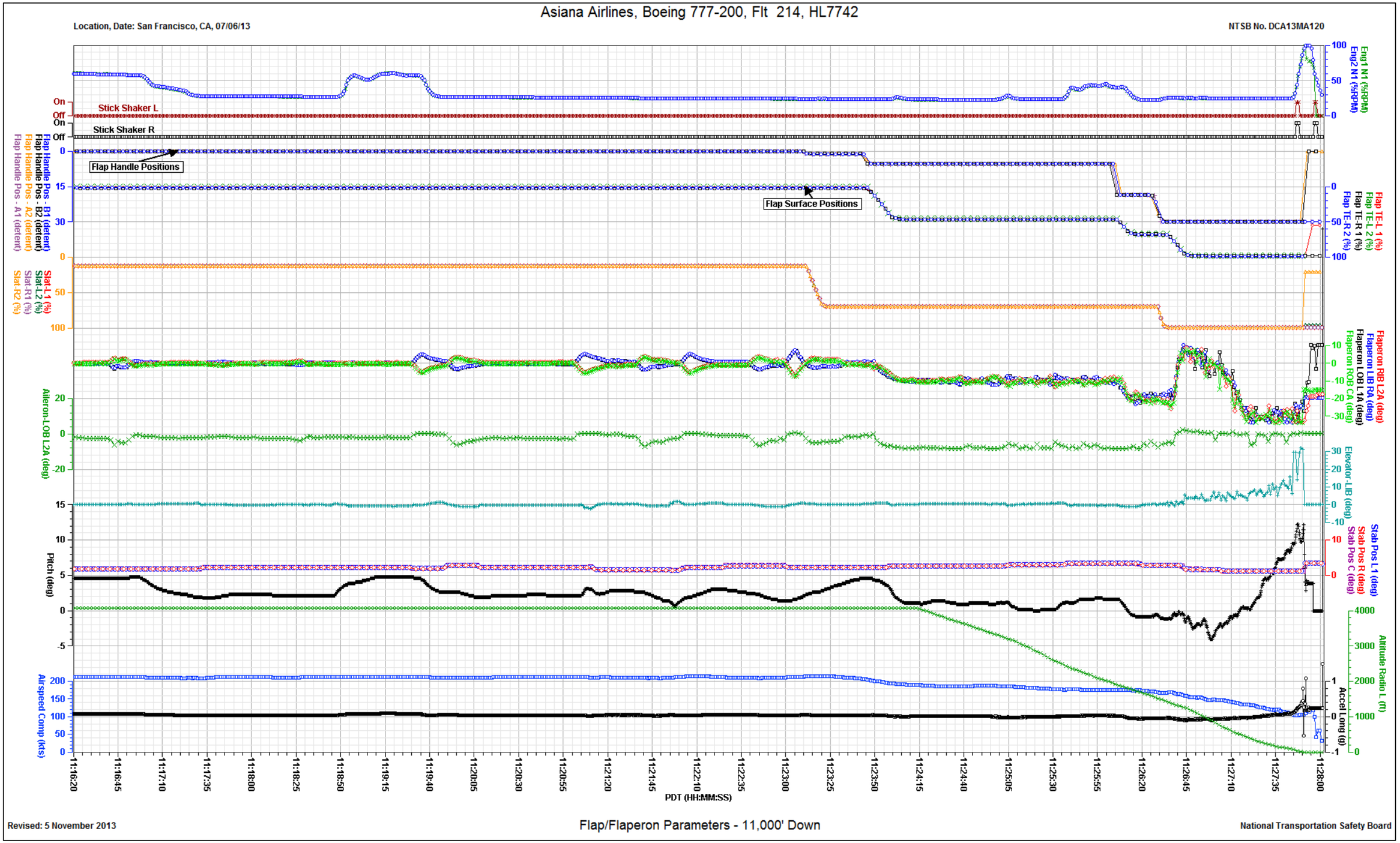


Figure 11 - Spoiler parameters from 11,000' through the end of the recording.

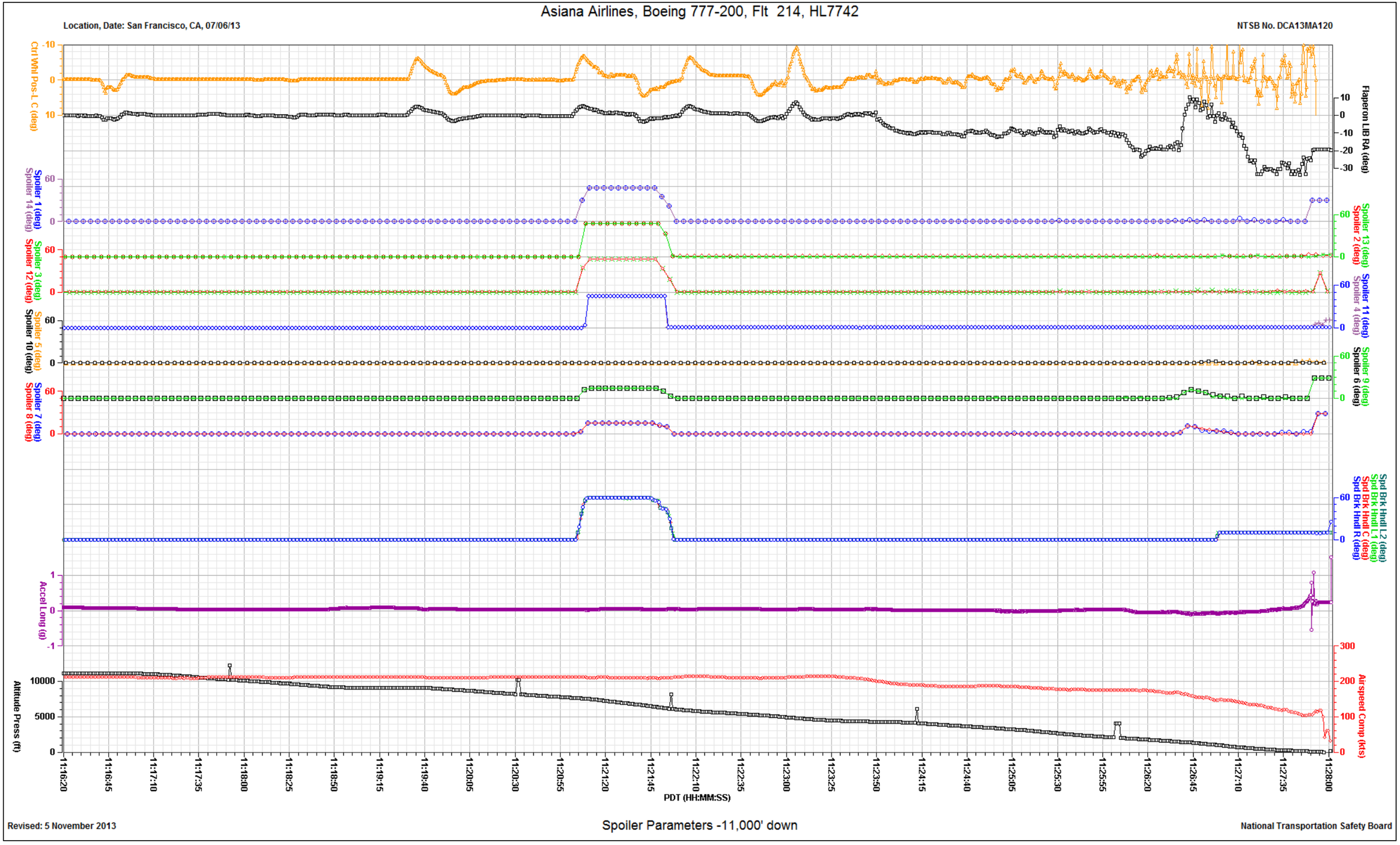


Figure 12 - Stall protection and vertical speed parameters from 11,000' through the end of the recording.

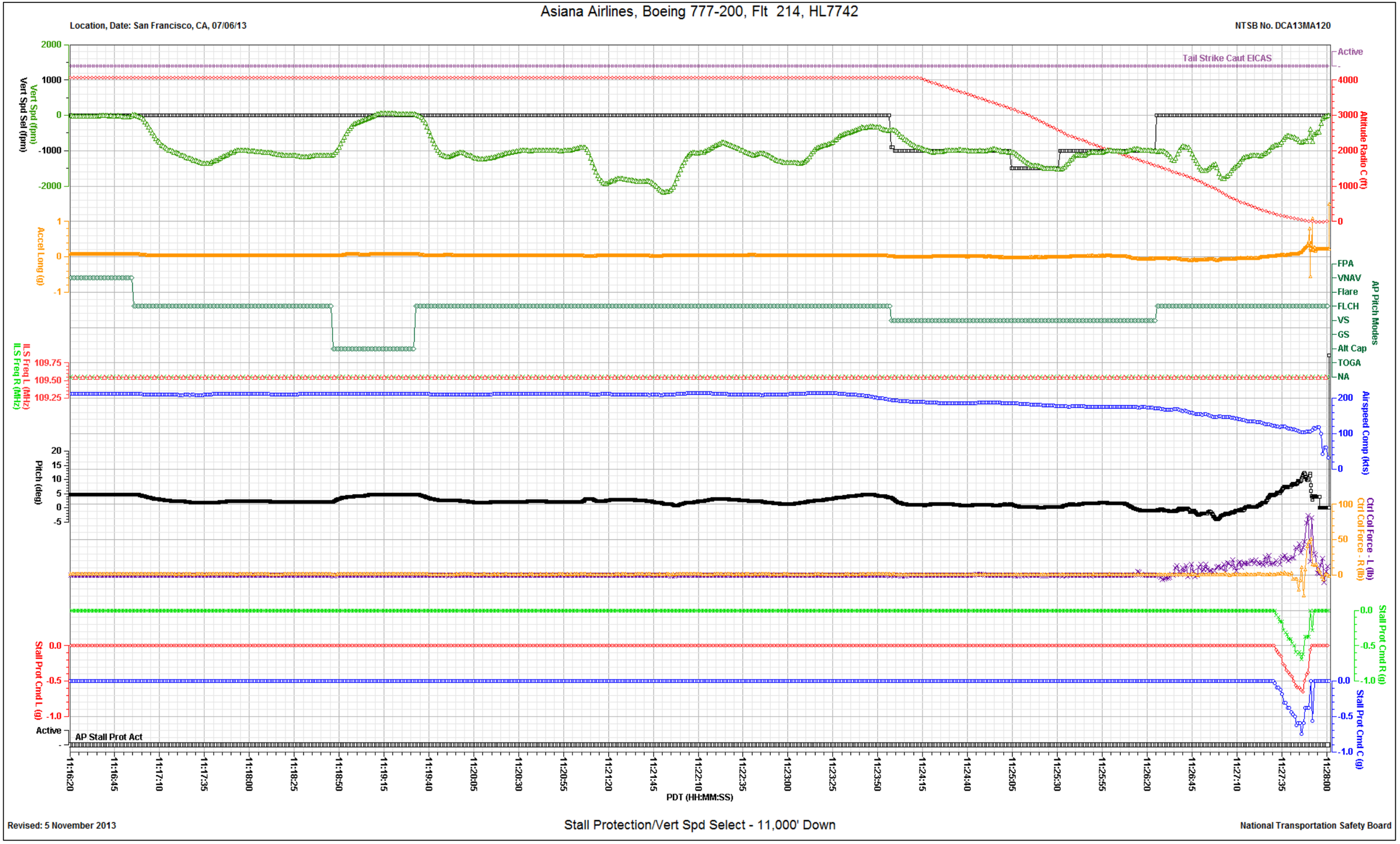


Figure 13 - GPWS and EGPWS discrete parameters for the last 2.5 minutes of the flight.

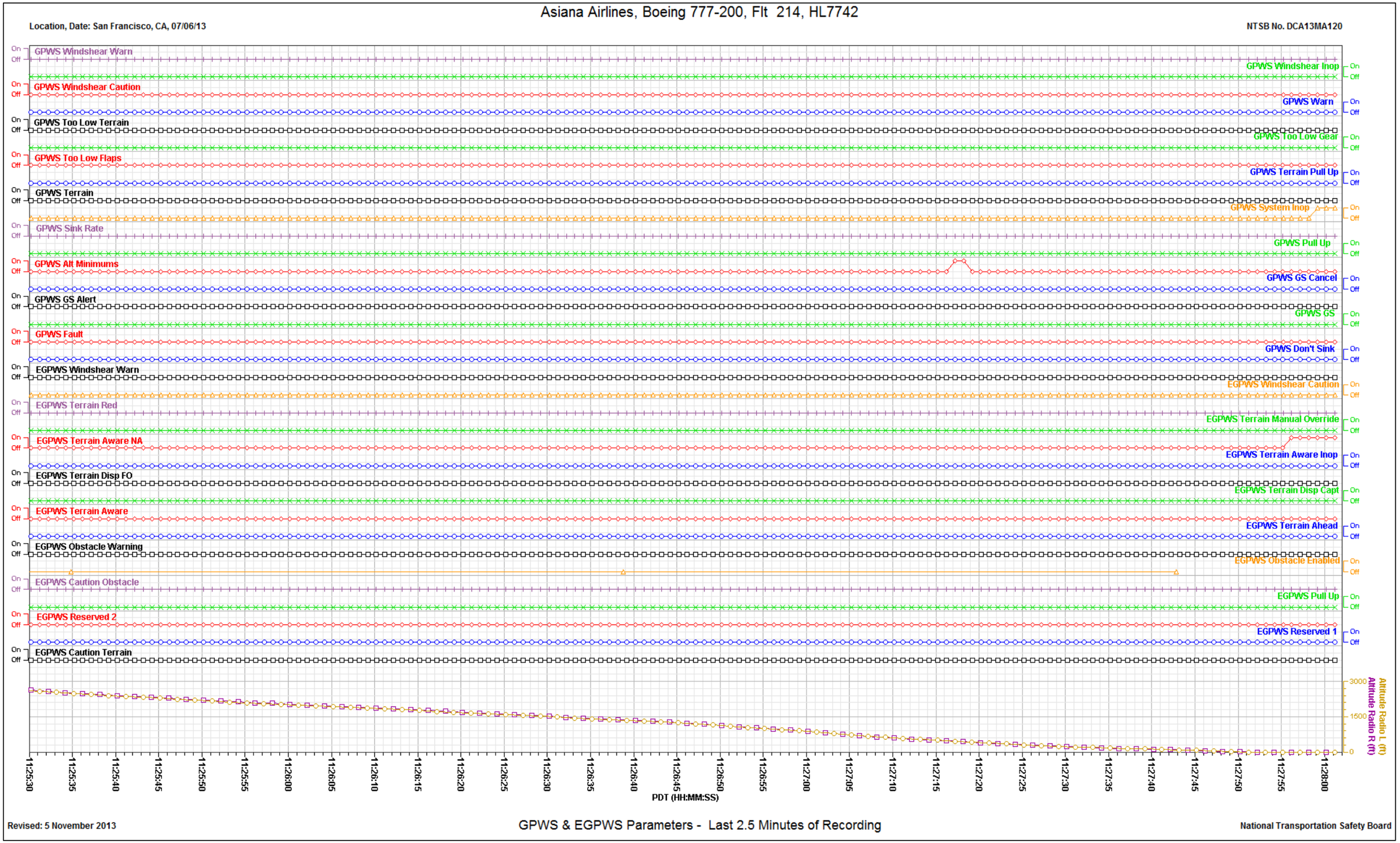


Figure 14 - Landing gear, latitude and longitude parameters from 11,000' through the end of the recording.

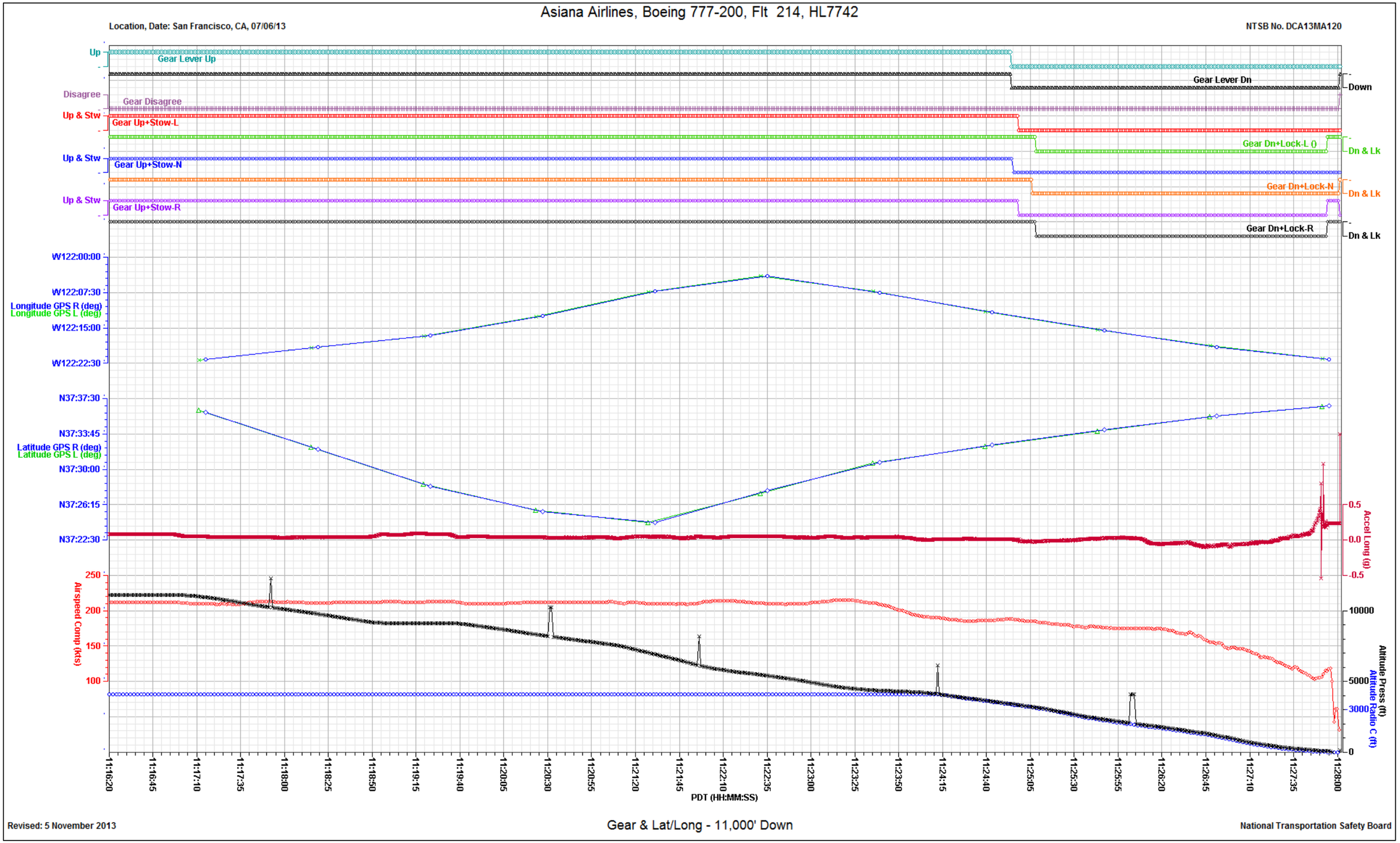
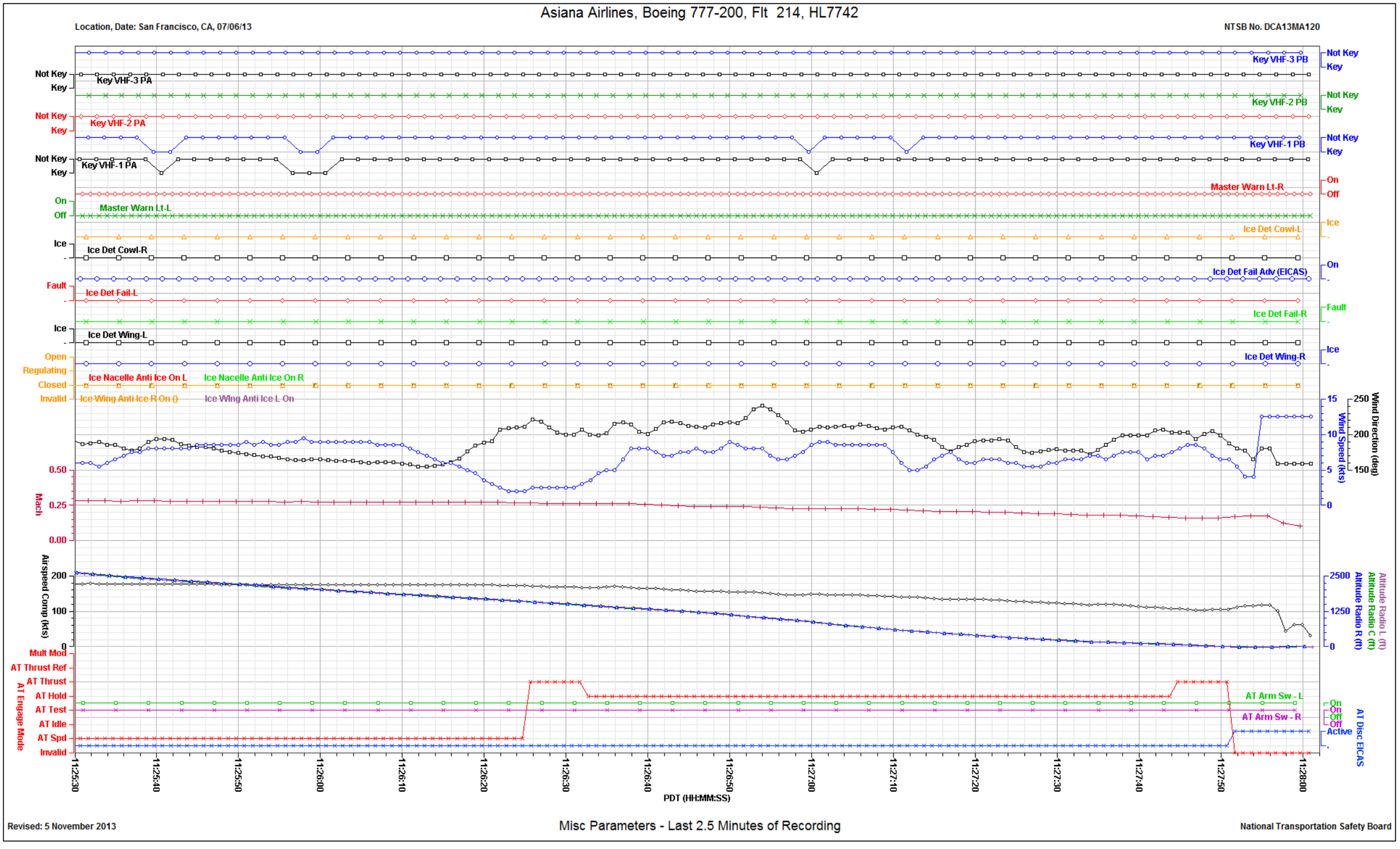


Figure 15 - Miscellaneous parameters for the last 2.5 minutes of the flight.



APPENDIX A

This appendix describes the FDR parameters provided and verified in this report. Table A-1 lists the parameters and Table A-2 describes the unit abbreviations used in this report.

Table A-1. Verified and provided FDR parameters.

Parameter Name	Plot/Table Name	Units
Lateral Acceleration	Accel Lat	g
Longitudinal Acceleration	Accel Long	g
Vertical Acceleration	Accel Vert	g
AFDS Localizer Mode Armed	AFDS LOC Mode Armed	
AFDS Pitch Mode Failed	AFDS Pitch Mode Fail	
AFDS Roll Mode Failed	AFDS Roll Mode Fail	
Left Outboard Aileron Position	Aileron-LOB L2A	deg
Left Inboard Aileron Position	Aileron-LIB CA	deg
Right Inboard Aileron Position	Aileron-RIB RA	deg
Right Outboard Aileron Position	Aileron-ROB L1A	deg
Computed Airspeed	Airspeed Comp	kts
Altitude Alert Caution EICAS Message	Altitude Alert Caut EICAS	
Pressure Altitude	Altitude Press	ft
Left Radio Altitude	Altitude Radio L	ft
Center Radio Altitude	Altitude Radio C	ft
Right Radio Altitude	Altitude Radio R	ft
Left Indicated Angle of Attack	AOA Ind L	deg
Right Indicated Angle of Attack	AOA Ind R	deg
Autopilot Engaged	AP Engage	
Left Autopilot Engage Request Switch	AP Eng Req Sw-L	
Right Autopilot Engage Request Switch	AP Eng Req Sw-R	
Left Autopilot Pitch Command	AP Pitch Cmd L	g
Center Autopilot Pitch Command	AP Pitch Cmd C	g
Right Autopilot Pitch Command	AP Pitch Cmd R	g
Autopilot/Flight Director System Engaged Pitch Mode	AP Pitch Modes	
Left Autopilot Pitch/Roll Engaged	AP Pitch Roll Engd-L	
Center Autopilot Pitch/Roll Engaged	AP Pitch Roll Engd-C	
Right Autopilot Pitch/Roll Engaged	AP Pitch Roll Engd-R	
Autopilot/Flight Director System Engaged Roll Mode	AP Roll Modes	
Mode Control Panel Selected Altitude	AP Sel Altitude	ft
Mode Control Panel Selected Airspeed	AP Sel Speed	kts
Autopilot Stall Protection Active	AP Stall Prot Act	
Left Auto Throttle Switch Selected On	AT Arm Sw - L	
Right Auto Throttle Switch Selected On	AT Arm Sw - R	
Auto Throttle Climb Limit Mode	AT Climb Lim Mode	
Auto Throttle Continuous Limit Mode	AT Cont Lim Mode	
Auto Throttle Cruise Limit Mode	AT Cruise Lim Mode	
Auto Throttle Disconnect EICAS Message	AT Disc EICAS	
Auto Throttle Engaged Mode	AT Engage Mode	
Auto Throttle Go Around Limit Mode	AT GA Limit Selected	
Auto Throttle Left Servo Only	AT L Servo Only	
Auto Throttle Right Servo Only	AT R Servo Only	
Auto Throttle Reference Mode Invalid	AT Thr Ref Mode Invalid	
Left Control Column Force	Ctrl Col Force - L	lbs
Right Control Column Force	Ctrl Col Force - R	lbs
Left Control Column Position (Left Source)	Ctrl Col Pos-L L1	deg
Left Control Column Position (Center Source)	Ctrl Col Pos-L C	deg
Left Control Column Position (Right Source)	Ctrl Col Pos-L R	deg

Parameter Name	Plot/Table Name	Units
Right Control Column Position (Left Source)	Ctrl Col Pos-R L2	deg
Right Control Column Position (Center Source)	Ctrl Col Pos-R C	deg
Right Control Column Position (Right Source)	Ctrl Col Pos-R R	deg
Control Wheel Force	Ctrl Wheel Force	lbs
Left Control Wheel Position (Left Source)	Ctrl Whl Pos-L L1	deg
Left Control Wheel Position (Center Source)	Ctrl Whl Pos-L C	deg
Left Control Wheel Position (Right Source)	Ctrl Whl Pos-L R	deg
Right Control Wheel Position (Left Source)	Ctrl Whl Pos-R L2	deg
Right Control Wheel Position (Center Source)	Ctrl Whl Pos-R C	deg
Right Control Wheel Position (Right Source)	Ctrl Whl Pos-R R	deg
Drift Angle	Drift Angle	deg
EGPWS Caution Obstacle	EGPWS Caution Obstacle	
EGPWS Caution Terrain	EGPWS Caution Terrain	
EGPWS Obstacle Enabled	EGPWS Obstacle Enabled	
EGPWS Obstacle Warning	EGPWS Obstacle Warning	
EGPWS Pull Up	EGPWS Pull Up	
EGPWS Reserved for Future Discrete 1	EGPWS Reserved 1	
EGPWS Reserved for Future Discrete 2	EGPWS Reserved 2	
EGPWS Terrain Ahead	EGPWS Terrain Ahead	
EGPWS Terrain Aware	EGPWS Terrain Aware	
EGPWS Terrain Aware Inoperative	EGPWS Terrain Aware Inop	
EGPWS Terrain Aware Not Available	EGPWS Terrain Aware NA	
Captain EGPWS Terrain Displayed	EGPWS Terrain Disp Capt	
First Officer EGPWS Terrain Displayed	EGPWS Terrain Disp FO	
EGPWS Terrain Manual Override	EGPWS Terrain Manual Override	
EGPWS Terrain Red	EGPWS Terrain Red	
EGPWS Windshear Caution	EGPWS Windshear Caution	
EGPWS Windshear Warn	EGPWS Windshear Warn	
Left Outboard Elevator Position	Elevator-LOB	deg
Left Inboard Elevator Position	Elevator-LIB	deg
Right Inboard Elevator Position	Elevator-RIB	deg
Right Outboard Elevator Position	Elevator-ROB	deg
Elevator Feel Actuator 1 Position	Elev Feel Act 1	in
Elevator Feel Actuator 2 Position	Elev Feel Act 2	in
Left Engine Burner Pressure	Eng1 Burner Pres	psi
Left Engine Commanded Thrust	Eng1 Cmd Thrust	EPR
Left Engine Exhaust Gas Temperature	Eng1 EGT	degC
Left Engine Pressure Ratio	Eng1 EPR	
Left Engine N1	Eng1 N1	%RPM
Left Engine N2	Eng1 N2	%RPM
Left Engine Throttle Rate Commanded	Eng1 Throt Rate Cmd	deg/s
Left Engine Throttle Lever Angle	Eng1 TLA	deg
Left Engine N1 Vibration	Eng1 Vib N1	
Left Engine N2 Vibration	Eng1 Vib N2	
Right Engine Burner Pressure	Eng2 Burner Pres	psi
Right Engine Commanded Thrust	Eng2 Cmd Thrust	EPR
Right Engine Exhaust Gas Temperature	Eng2 EGT	degC
Right Engine Pressure Ratio	Eng2 EPR	
Right Engine N1	Eng2 N1	%RPM
Right Engine N2	Eng2 N2	%RPM
Right Engine Throttle Rate Commanded	Eng2 Throt Rate Cmd	deg/s
Right Engine Throttle Lever Angle	Eng2 TLA	deg
Right Engine N1 Vibration	Eng2 Vib N1	
Right Engine N2 Vibration	Eng2 Vib N2	
Left Flight Director Pitch Command	FD Pitch Cmd L	deg

Parameter Name	Plot/Table Name	Units
Center Flight Director Pitch Command	FD Pitch Cmd C	deg
Right Flight Director Pitch Command	FD Pitch Cmd R	deg
Captain Flight Director Switch Selection	FD SW Sel Capt	
First Officer Flight Director Switch Selection	FD SW Sel FO	
Left Outboard Flaperon Position	Flaperon LOB L1A	deg
Left Inboard Flaperon Position	Flaperon LIB RA	deg
Right Inboard Flaperon Position	Flaperon RIB L2A	deg
Right Outboard Flaperon Position	Flaperon ROB CA	deg
Flap Handle Position Source A1	Flap Handle Pos - A1	detent
Flap Handle Position Source A2	Flap Handle Pos - A2	detent
Flap Handle Position Source B1	Flap Handle Pos - B1	detent
Flap Handle Position Source B2	Flap Handle Pos - B2	detent
Left Trailing Edge Flap 1	Flap TE-L 1	%
Left Trailing Edge Flap 2	Flap TE-L 2	%
Right Trailing Edge Flap 1	Flap TE-R 1	%
Right Trailing Edge Flap 2	Flap TE-R 2	%
Flight Director Engaged - Left	Flt Dir Engaged - L	
FMC Minimum Maneuver Speed	FMC Min Manuv Spd	kts
FMC Selected Reference Speed	FMC Sel Ref Spd	kts
Left Main Fuel Quantity	Fuel Qty L Main	lbs or kg
Center Main Fuel Quantity	Fuel Qty Center	lbs or kg
Right Main Fuel Quantity	Fuel Qty R Main	lbs or kg
Auxiliary Cell 1 Fuel Quantity	Fuel Qty Aux Cell1	lbs or kg
Auxiliary Cell 2 Fuel Quantity	Fuel Qty Aux Cell2	lbs or kg
Auxiliary Cell 3 Fuel Quantity	Fuel Qty Aux Cell3	lbs or kg
Total Fuel Quantity	Fuel Qty Total	lbs or kg
Fuel Units Status	Fuel Units Status	
Gear Disagree	Gear Disagree	
Landing gear Lever Down	Gear Lever Dn	
Landing gear Lever Up	Gear Lever Up	
Left Main Landing Gear Down and Locked	Gear Dn+Lock-L	
Nose Landing Gear Down and Locked	Gear Dn+Lock-N	
Right Main Landing Gear Down and Locked	Gear Dn+Lock-R	
Left Main Landing Gear Up and Stowed	Gear Up+Stow-L	
Nose Landing Gear Up and Stowed	Gear Up+Stow-N	
Right Main Landing Gear Up and Stowed	Gear Up+Stow-R	
Left Main Landing Gear Weight on Wheels	Gear WOW-L	
Nose Landing Gear Weight on Wheels	Gear WOW-N	
Right Main Landing Gear Weight on Wheels	Gear WOW-R	
GPWS Minimums	GPWS Alt Minimums	
GPWS Failed	GPWS Fault	
GPWS Glideslope	GPWS GS	
GPWS Glideslope Alert	GPWS GS Alert	
GPWS Glideslope Cancel	GPWS GS Cancel	
GPWS Pull Up	GPWS Pull Up	
GPWS Sink Rate	GPWS Sink Rate	
GPWS System Inoperative	GPWS System Inop	
GPWS Terrain	GPWS Terrain	
GPWS Terrain Pull Up	GPWS Terrain Pull Up	
GPWS Too Low Flaps	GPWS Too Low Flaps	
GPWS Too Low Gear	GPWS Too Low Gear	
GPWS Too Low Terrain	GPWS Too Low Terrain	
GPWS Warning	GPWS Warn	
GPWS Windshear Caution	GPWS Windshear Caution	
GPWS Windshear Inoperative	GPWS Windshear Inop	

Parameter Name	Plot/Table Name	Units
GPWS Windshear Warning	GPWS Windshear Warn	
FMC Gross Weight	Gross Weight FMC	lbs
Ground Speed	Ground Spd	kts
Displayed Heading	Heading Disp	deg
Magnetic Heading	Heading Mag	deg
Magnetic Heading Reference Selected	Heading Norm Ref Sel	
True Heading Reference Selected	Heading True Ref Sel	
Ice Detected Left Cowl	Ice Det Cowl-L	
Ice Detected Right Cowl	Ice Det Cowl-R	
Ice Detectors Failed EICAS Advisory	Ice Det Fail Adv (EICAS)	
Left Ice Detector Failed	Ice Det Fail-L	
Right Ice Detector Failed	Ice Det Fail-R	
Ice Detected Left Wing	Ice Det Wing-L	
Ice Detected Right Wing	Ice Det Wing-R	
Left Nacelle Anti-Ice On	Ice Nacelle Anti Ice On L	
Right Nacelle Anti-Ice On	Ice Nacelle Anti Ice On R	
Left Wing Anti-Ice On	Ice WIng Anti Ice L On	
Right Wing Anti-Ice On	Ice Wing Anti Ice R On	
Left Instrument Landing System Frequency	ILS Freq L	MHz
Center Instrument Landing System Frequency	ILS Freq C	MHz
Right Instrument Landing System Frequency	ILS Freq R	MHz
VHF 1 Keyed (Source PA)	Key VHF-1 PA	
VHF 1 Keyed (Source PB)	Key VHF-1 PB	
VHF 2 Keyed (Source PA)	Key VHF-2 PA	
VHF 2 Keyed (Source PB)	Key VHF-2 PB	
VHF 3 Keyed (Source PA)	Key VHF-3 PA	
VHF 3 Keyed (Source PB)	Key VHF-3 PB	
Left GPS Latitude Most Significant Part	Latitude GPS L MSP	deg
Left GPS Latitude Least Significant Part	Latitude GPS L LSP	deg
Right GPS Latitude Most Significant Part	Latitude GPS R MSP	deg
Right GPS Latitude Least Significant Part	Latitude GPS R LSP	deg
Left Localizer Deviation	Loc Deviation L	ddm
Center Localizer Deviation	Loc Deviation C	ddm
Right Localizer Deviation	Loc Deviation R	ddm
Left GPS Longitude Most Significant Part	Longitude GPS L MSP	deg
Left GPS Longitude Least Significant Part	Longitude GPS L LSP	deg
Right GPS Longitude Most Significant Part	Longitude GPS R MSP	deg
Right GPS Longitude Least Significant Part	Longitude GPS R LSP	deg
Mach Number	Mach	
Left Master Warning Light	Master Warn Lt-L	
Right Master Warning Light	Master Warn Lt-R	
Mode Control Panel Speed Display Blank	MCP Spd Disp Blnk	
Pitch Attitude	Pitch	deg
Left Pitch Trim Reference Speed	Pitch Trim Ref Spd-L	kts
Center Pitch Trim Reference Speed	Pitch Trim Ref Spd-C	kts
Right Pitch Trim Reference Speed	Pitch Trim Ref Spd-R	kts
Roll Attitude	Roll	deg
Lower Rudder Position	Rudder-L RA	deg
Middle Rudder Position	Rudder-M L1A	deg
Upper Rudder Position	Rudder-U CA	deg
Rudder Pedal Position (Source L1A)	Rudder Ped Pos L1A	in
Rudder Pedal Position (Source L2A)	Rudder Ped Pos L2A	in
Rudder Pedal Position (Source CA)	Rudder Ped Pos CA	in
Rudder Pedal Position (Source RA)	Rudder Ped Pos RA	in
Leading Edge Slat L1 Position	Slat-L1	%

Parameter Name	Plot/Table Name	Units
Leading Edge Slat L2 Position	Slat-L2	%
Leading Edge Slat R1 Position	Slat-R1	%
Leading Edge Slat R2 Position	Slat-R2	%
Speed Brake Handle Position (Source L1)	Spd Brk Hndl L1	deg
Speed Brake Handle Position (Source L2)	Spd Brk Hndl L2	deg
Speed Brake Handle Position (Source C)	Spd Brk Hndl C	deg
Speed Brake Handle Position (Source R)	Spd Brk Hndl R	deg
Spoiler 1 Position	Spoiler 1	deg
Spoiler 2 Position	Spoiler 2	deg
Spoiler 3 Position	Spoiler 3	deg
Spoiler 4 Position	Spoiler 4	deg
Spoiler 5 Position	Spoiler 5	deg
Spoiler 6 Position	Spoiler 6	deg
Spoiler 7 Position	Spoiler 7	deg
Spoiler 8 Position	Spoiler 8	deg
Spoiler 9 Position	Spoiler 9	deg
Spoiler 10 Position	Spoiler 10	deg
Spoiler 11 Position	Spoiler 11	deg
Spoiler 12 Position	Spoiler 12	deg
Spoiler 13 Position	Spoiler 13	deg
Spoiler 14 Position	Spoiler 14	deg
Stabilizer Position (Source L1)	Stab Pos L1	deg
Stabilizer Position (Source C)	Stab Pos C	deg
Stabilizer Position (Source R)	Stab Pos R	deg
Left Stabilizer Down Arm Switch	Stab Trim Arm Sw Dn-L	
Right Stabilizer Down Arm Switch	Stab Trim Arm Sw Dn-R	
Left Stabilizer Up Arm Switch	Stab Trim Arm Sw Up-L	
Right Stabilizer Up Arm Switch	Stab Trim Arm Sw Up-R	
Left Stabilizer Down Control Switch	Stab Trim Ctrl Sw Dn-L	
Right Stabilizer Down Control Switch	Stab Trim Ctrl Sw Dn-R	
Left Stabilizer Up Control Switch	Stab Trim Ctrl Sw Up-L	
Right Stabilizer Up Control Switch	Stab Trim Ctrl Sw Up-R	
Left Stall Protection Command	Stall Prot Cmd L	g
Center Stall Protection Command	Stall Prot Cmd C	g
Right Stall Protection Command	Stall Prot Cmd R	g
Left Stick Shaker	Stick Shaker L	
Right Stick Shaker	Stick Shaker R	
Tail Strike EICAS Caution	Tail Strike Caut EICAS	
Static Air Temperature	Temp SAT	degC
Total Air Temperature	Temp TAT	degC
GMT Hours	Time GMT Hrs	hrs
GMT Minutes	Time GMT Min	min
GMT Seconds	Time GMT Sec	sec
Vertical Speed	Vert Spd	fpm
Selected Vertical Speed	Vert Spd Sel	fpm
Wind Direction	Wind Direction	deg
Wind Speed	Wind Speed	kts

NOTE: Parameters with a blank unit description are typically discrete parameters. A discrete parameter is usually a 1-bit parameter that is either a 0 state or a 1 state where each state is uniquely defined for each parameter. Other parameters such as Engine Pressure Ratio, Mach Number or vibrations are a ratio which have no units.

Table A-2. Unit abbreviations.

Units Abbreviation	Description
%	percent
%RPM	percent of maximum RPMs
ddm	degree of depth modulation
deg	degrees
deg/s	degrees per second
degC	degrees Celsius
detent	detent
EPR	engine pressure ratio
fpm	feet per minute
ft	feet
g	g's
hrs	hours
in	inches
kts	knots
lbs	pounds
lbs or kg	pounds or kilograms (as indicated by an associated discrete parameter)
MHz	megahertz
min	minutes
psi	pounds per square inch
sec	seconds

APPENDIX B

This appendix describes the QAR parameters provided and verified in this report. Table B-1 lists the parameters used in this report. The unit abbreviations for QAR parameters are the same as those provided for FDR parameters in Appendix A, Table A-2.

Table B-1. Verified and provided QAR parameters.

Parameter Name	Plot/Table Name	Units
Computed Airspeed	Airspeed	kts
Pressure Altitude	Altitude Press	ft
Flight Director On Attitude Captain	FD On Att Capt	
Flight Director On Attitude First Officer	FD On Att FO	
Flight Director On Flight Path Vector Captain	FD On FPV Capt	
Flight Director On Flight Path Vector First Officer	FD On FPV FO	
Center Main Fuel Weight	Fuel Weight C	lbs
Left Main Fuel Weight	Fuel Weight L Main	lbs
Right Main Fuel Weight	Fuel Weight R Main	lbs
Total Fuel Weight	Fuel Weight Tot	lbs
Flight Management Function Zero Fuel Weight	Zero Fuel Weight FMF	lbs
GMT Month	Time Month	month
GMT Day	Time Day	day
GMT Hours	Time GMT Hrs	hrs
GMT Minutes	Time GMT Min	min
GMT Seconds	Time GMT Sec	sec